BRIEFER ARTICLES.

NOTE ON THE MECHANICS OF THE SEED-BURYING AWNS OF STIPA AVENACEA.

(WITH FIVE FIGURES)

IN the parts of many plants where hygroscopic movements take place in dead tissues, the cause is found in thick-walled mechanical cells of peculiar structure or varying chemical composition.

The ripe and dry awn of *Stipa avenacea*, holding the seed at the lower end, is strongly twisted over half its length next to the seed in a direction opposite to the movement of watch hands. The remainder of the awn, not having the spiral structure of the former, is not twisted, but is bent at an angle to the body of the awn, thus furnishing a brace or support when the seed begins its boring motion, driven by the alternate twisting and untwisting of the dry or wet awn. Little barbules on the upper part of the awn directed away from the seed, assist its progress forward while preventing any backward movement.

The seed is tipped with a short, sharp point, slightly curved, the better to lead the way into the ground. Stiff hair-like barbs on the lower portion of the seed hold it in the ground when once started. The onward motion is still farther assisted by the increased length of the awn when wet, which amounts, by actual measurement, to 20 per cent. of the whole length. On drying a corresponding withdrawal of the seed is prevented by the barbs. So the alternate wetting and drying of the awn serves the twofold purpose of moving the seed about (although this is, no doubt, more commonly accomplished by being fastened with its appendages to some moving object) and placing it in a favorable position in the earth for germination.

The awns of Avena act much more promptly than those of Stipa; the latter take several minutes to straighten out in water, while one of *Avena barbata*, thrown on water, made five or six turns in twice as many seconds. The moist awn straightens out completely. When placed in caustic potash or other macerating fluid it twists with watch

hands almost as strongly as it does in the opposite direction when dried.

The minute structure of the awn furnishes an explanation of the phenomena here described. A thorough investigation of this subject was made by A. Zimmerman[1] whose purpose was to gain a more accurate insight into the torsion mechanism of the awns of wild grasses. He gives Hildebrand credit for first attempting to explain mechanically the hygroscopic torsion. His explanation was considered incorrect, and was not in accordance with the views of Nägeli and Schwendener, who held that the seat of the mechanism is in the individual cell. Francis Darwin afterward confirmed this view. Zimmermann found that in the awn of *Avena sterilis* (with which, he says, *Stipa pennata* agrees in all essentials), the twisting power is confined solely to the outer row of cells whose structure shows a spiral arrangement. Both the arrangement of the pits in the walls of these cells and the appearance of the material in polarized light evince their spiral structure. The cells within this outer row have no tendency to twist, but the author thinks they assist the general movement by their contraction on drying. While so far little account had been taken of the micellar arrangement in the cells, the explanation of the mechanism was thus carried back to the molecular structure of the cells.

The present observations confirm those of others in locating the cause of the twisting of the awn in the individual cells *and show that not only a layer of cells but all of the mechanical cells are active in bringing about this result.*

As is well known, the twisted portion of the awn is composed principally of sclerenchyma cells with a fibro-vascular bundle in the center and a band of chlorophyll bearing tissue on each side (*fig. 1*). The latter, however, has nothing to do with the torsion. A striking peculiarity of the mechanical cells is the narrowness and eccentricity of their lumina; furthermore, this eccentricity in all the cells is alike, so that the lumina lie nearest the center of the awn (see *figs. 1* and *3*).

Strong Schultz's solution shows that the material immediately around each lumen is still very much like cellulose; that it swells and contracts more than the outer and denser layers of the cell wall is evident, since the surface of a cross section of a single cell in caustic potash is convex, but when washed and dried is concave.

[1] Jahrbücher für wissenschaftl. Bot. **7**: 542.

As before stated, Zimmermann inferred the spiral arrangement of the material in the walls of the outer cells from the direction of the pits, and from the appearance in polarized light; but according to him no one had succeeded in bringing out clearly any striation.

After treatment with strong caustic potash and then with dilute glycerine, I found such striations quite well marked, passing obliquely

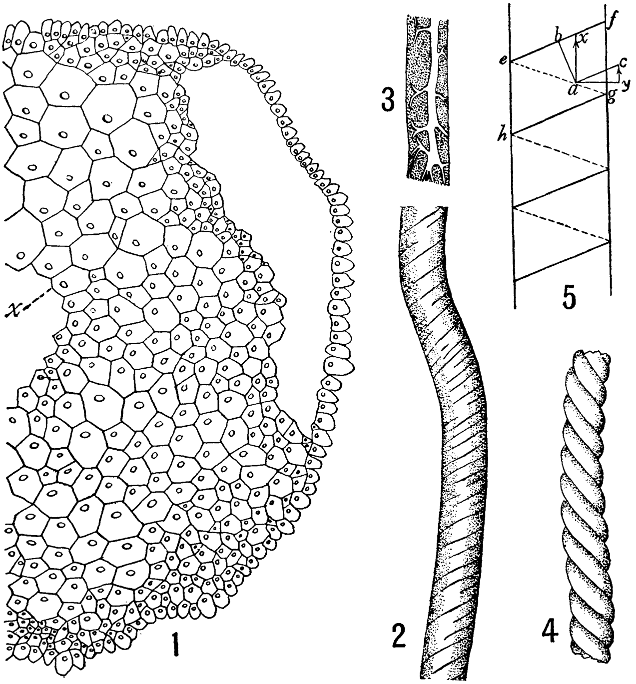

FIG. 1. Cross section of half an awn showing the disposition of the mechanical cells.—FIG. 2. An isolated cell (dry) showing the spiral arrangement of the material in normal condition.—FIG. 3. An optical longitudinal section of one of the cells (x) shown in figure 2.—FIG. 4. One of the cells after soaking in a macerating agent.—FIG. 5. Diagram showing the resultant of forces that may cause torsion in the mechanical cells.—FIGS. 1, 3, and 4 are enlarged 115 times.

across the cell (*fig. 2*). When seen through the cell in the opposite wall, they pass in opposite direction to those in the wall on the nearer side. This makes patent the spiral structure of the cell wall, denser (more highly refractive) layers alternating with layers which are less dense.

That the outer layer of cells is not, in this case at least, exclusively instrumental in effecting torsion, was proved by scraping off the outer two thirds of a wet awn, when the remaining central portion, on drying, was seen to twist as perfectly as the intact awn. Another evidence of this fact is, that after maceration, the largest cells, which belong to the middle portion of the awn, are found twisted quite as much as the smaller outside cells (*fig. 4*). This also agrees with Darwin's observations, quoted by Zimmermann (*l. c.*, p. 551).

There can be no doubt, then, that the mechanism is in the individual cells, and in the inner as well as the outer; and we have as an explanation of the hygroscopic torsion, thick-walled mechanical cells, each with very small eccentric lumen which is surrounded by a layer of cellulose-like material, the molecular structure of which is spiral.

There are two causes present, either of which may under favorable circumstances produce torsion:

First, the mechanical cell may be considered as a hollow cylinder whose walls are made up of material in layers of alternating density. In the diagram (*fig. 5*) let *fe* and *hg* represent dense layers of material while the less dense are the layers between. When dry, the cell is twisted with watch hands. Water enters first into the less dense layers forcing the micellæ in all directions. Two of these forces are principally concerned here. The one, *ab*, acting at right angles to the spiral plane of more dense material, may be resolved into its two components *ax* and *xb*. One of these acts tangentially and tends simply to increase the diameter of the cell; the other moves the spiral plane in such a way as to increase the angle it makes with the axis of the cell, producing, in the wall of the cell toward us, motion from right to left. The other force, *ac*, may be resolved into its components, *ay* and *cy*, the first of which again merely tends to increase the diameter of the cell, and the second, acting nearly parallel to the component *ax*, will strengthen it. In the opposite wall of the cell the same forces will be found to produce the same result, but when seen through the cell, the direction of motion will be just opposite to that in the wall on this side. There can be but one result from the action of such forces — the two forces on opposite sides of a cell, acting in opposite directions about its center, will produce torsion.

Second, the eccentric position of the cellulose-like material about the lumen of the cell throws the center of the more dense material to one side of its axis, so that the dry cell on imbibing water will curve

with the denser material on the concave side; at least this would ordinarily take place. But such a bend in one plane is changed to a twist whenever the proper forces are present. In the case before us, we have not only the proper forces to cause a twist but also to give the motion constancy of direction, *i. e.*, with watch hands. These forces are found in the spiral arrangement of the material. In this case we should expect a waving or serpentine bend rather than a close twist. The fact that many cells are found, after applying reagents, in all stages from a beginning bend in one plane to a wavy twist, leads to the conclusion that this is, perhaps, the principal force of torsion when the lumen is very eccentric.

It is probable that both these causes act in conjunction to produce the generally resulting perfect torsion.— L. MURBACH, *Central High School, Detroit, Mich.*

SOME NEW SPECIES OF WYOMING PLANTS.

Silene Tetonensis.—Stems several, somewhat cespitose from a multicipital caudex, 10–25^{cm} high, 1–7-flowered: minutely pubescent throughout, glandular above and often throughout, the leaves often glabrous except on the margins: leaves connate at base and sheathing by somewhat scarious membranes, the petioles often sparsely ciliate; the radical long-petioled, linear or narrowly oblanceolate, 2–8^{cm} long, 2–6^{mm} wide; the cauline linear or the lowest pair narrowly oblanceolate: calyx obovoid, 7–10^{mm} long, with 10 purplish nerves, these anastomosing somewhat near the summit, 5-toothed, the teeth rotund or rhomboid-triangular, obtuse with very broad membranous margins: petals 9–12^{mm} long, greenish-white or rose-color, more or less exserted; the claw 3^{mm} broad, spatulate, with the margins entire or bluntly toothed near the summit, not at all auricled, 3-nerved, the nerves branched and anastomosing in the limb; this 3^{mm} long, as broad as the claw or generally a little narrower, with no lateral lobes, emarginate or cleft to the middle, the lobes entire and rounded, the appendages much broader than long and bluntly toothed: stamens nearly as long as the claws of the petals, the filaments glabrous; styles 3, 1^{mm} long: carpophore very short.

Related to the western *S. Watsoni*, but is readily distinguished from that by its broader radical leaves and very different petals.